Results After Lumbar Decompression With and Without Discectomy: Comparison of the Transspinous and Conventional Approaches

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OBJECTIVE: To evaluate the efficacy of the transspinous approach compared with the conventional approach in single-level lumbar laminotomies with and without discectomies.

METHODS: Forty consecutive patients underwent single-level lumbar decompression with or without a discectomy. The first 20 patients underwent surgery by the conventional approach (11 with discectomy and 9 without), and the transspinous approach was used in the remaining 20 patients (11 with discectomy and 9 without). Results between the groups were assessed by comparing the following measures: length of inpatient hospital stay, postoperative pain and analgesia use, estimated blood loss, rate of postoperative disability and complications, and incision length.

RESULTS: The groups did not differ significantly with respect to age, level of pathology, insurance status, or type of analgesia used. The primary outcome was physical disability, measured using the Roland-Morris Disability Questionnaire. The secondary outcome was pain intensity, measured using the Brief Pain Inventory. Patients who underwent the transspinous approach had better outcomes across all measures with significance appreciated in those who underwent transspinous decompression with discectomies. Other statistically significant differences were identified in incision length and postoperative analgesia use at the end of 1 week. No statistically significant differences were identified in the rates of complications, estimated blood loss, inpatient narcotic analgesia use, or length of inpatient hospital stay.

CONCLUSION: Patients who underwent single-level lumbar decompression with or without discectomy had similar outcomes as those who underwent the conventional approach. Although of modest clinical significance, the transspinous approach may afford early mobilization and reduced postoperative pain while providing a satisfactory neurological and functional outcome.

KEY WORDS: Discectomy, Lumbar decompression, Lumbar stenosis, Minimally invasive surgery

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Lumbar spinal stenosis is the most common degenerative condition of the lumbar spine.[1-10] Nearly 75 years have elapsed since the description of the conventional open laminectomy technique by Mixter[11] and Barr and Riseborough,[12] and it continues to be the most widely used technique as well as the gold standard for lumbar decompression, with a satisfactory outcome in 55% to 87% of patients.[5,6,13-18] Drawbacks of this conventional technique include significant blood loss, postoperative incisional and back pain, prolonged recovery time, impaired spinal function, possible iatrogenic spinal instability, and paraspinal muscular atrophy.[2,3,5-7,10,13,19-30] To offset some of these issues, various alternative open and minimally invasive techniques such as microdecompression,[24,31,32] multiple microscopic laminotomy,[33,34] open-door and distraction laminoplasty,[35-37] and unilateral laminectomy for bilateral decompression[33] have been described.[38] Most of these techniques are generally very time-consuming, may not achieve sufficient decompression, and attempt to minimize but do not eliminate paraspinal muscle injury.

Reports of successful spinous process osteotomies for spinal stenosis decompression have been described,[30,39] but these may cause spinous process instability. Furthermore, they do not eliminate damage to the paraspinal muscles because at least one-half of the paraspinal musculature has to be dissected away from the

ABBREVIATIONS: BPI, Brief Pain Inventory; **RDQ-24**, Roland-Morris Disability Questionnaire

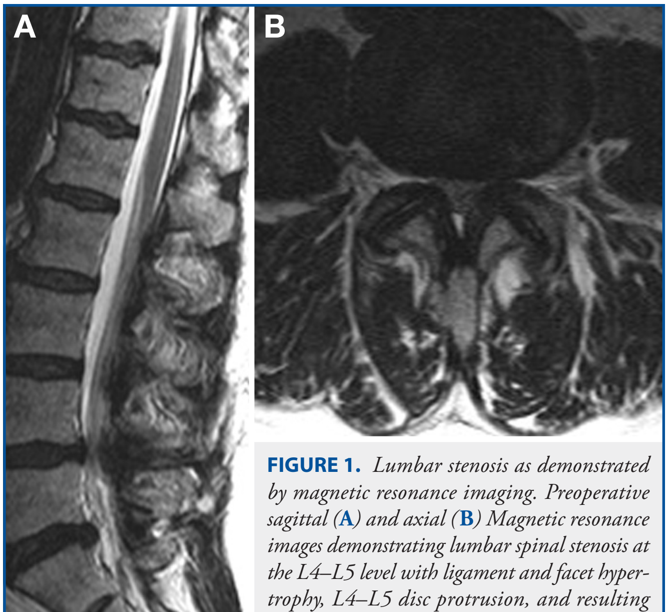


FIGURE 1. *Lumbar stenosis as demonstrated by magnetic resonance imaging. Preoperative sagittal (**A**) and axial (**B**) Magnetic resonance images demonstrating lumbar spinal stenosis at the L4–L5 level with ligament and facet hypertrophy, L4–L5 disc protrusion, and resulting biforaminal narrowing.*

spinous process. Only the spinous process–splitting laminectomy by Watanabe et al,[40] the chimney sublaminar decompression by Lin et al,[41] and the Marmot operation (split-spinous process laminotomy) by Cho et al,[38] have attempted to eliminate paraspinal muscle injury completely while simultaneously achieving satisfactory neurological outcome. We developed an operative technique that is a variant of the chimney sublaminar and split spinous process laminotomy techniques for decompression of lumbar spinal stenosis. In this report, we describe and evaluate the efficacy of this new minimally invasive transspinous approach used in patients with lumbar stenosis with or without associated disc herniation (Fig. 1). Notably, in this procedure, unlike its counterparts, only a portion of the spinous process is resected and the interspinous ligament split, with its periosteal layers being left intact without manipulation of the paraspinal muscles.

PATIENTS AND METHODS

Patient Population

A retrospective chart review identified 75 patients who had undergone lumbar decompression with and without discectomy during the period from July 2006 to May 2008. Of this population, 40 patients presented with symptoms of single-level lumbar stenosis and neurogenic claudication. The first 20 consecutive patients underwent surgery in which the conventional approach was used, and the remaining 20 consecutive patients underwent surgery in which the transspinous approach was used. Eighteen patients underwent lumbar decompression only (9 transspinous and 9 conventional), and the other 22 patients (11 transspinous and 11 conventional) underwent lumbar decompression with discectomy (Table 1). The mean age at the time of operation was 53 years (age range, 28–78 years), and 36 patients reported symptoms of back pain with neurogenic claudication, with the remaining 4 presenting only with back pain.

In the conventional group, 16 patients had back pain with symptoms of neurogenic claudication (8 left sided, 6 right sided, and 2 bilateral). Four patients had lower extremity weakness (grade 4 of 5), and 3 patients had footdrop. Symptoms secondary to work-related blunt trauma developed in 2 patients. In the transspinous group, 17 patients had back pain with symptoms of neurogenic claudication (7 left sided, 6 right sided, and 4 bilateral). Three patients had left lower extremity weakness (grade 4 of 5), and 2 patients had associated footdrop. Symptoms secondary to work-related blunt trauma developed in 3 patients, and 1 patient had grade I spondylolisthesis (atraumatic).

In the conventional group who underwent decompression only, 7 patients underwent decompression at the L4 level, 1 at L3, and 1 at L5. In the transspinous group who underwent decompression only, 6 patients underwent decompression at the L4 level, 1 at L2, 1 at L3, and 1 at L5. In the conventional group who underwent decompression with discectomy, 5 patients underwent surgery at the L5–S1 level, 4 at L4–L5, 1 at L2–L3, and 1 at L3–L4. In the transspinous group who underwent decompression with discectomy, 7 patients underwent surgery at the L4–L5 level, 2 at L5–S1, 1 at L2–L3, and 1 at L3–L4. In all patients, surgery was performed by the senior author (L.S.C.).

Surgical Technique: The Transspinous Approach

Transspinous Lumbar Decompression Only

All patients underwent single-level transspinous lumbar decompression. The length of the spinous process was determined by preoperative imaging (magnetic resonance imaging or computed tomography) before the procedure. After anesthesia was induced in the patients, they were placed in the prone position on a Wilson frame (Mizuho OSI, Union City, CA), and the levels of spinous processes were located using lateral x-rays from a portable C-arm fluoroscope. The operative field was then prepared and draped in the usual fashion. A crucifix incision template radiographic marker (DePuy Spine, Inc., Raynham, Massachusetts) was used to locate the spinous process of interest using anteroposterior radiographs from the C-arm fluoroscope. Once the appropriate spinous process was identified, the proposed incision site was marked on the skin and infiltrated with a local anesthetic agent. A no. 10 scalpel was used to make the incision, and a Weitlander or angled cerebellar self-retaining retractor was used to retract the skin edges. Subcutaneous fat was dissected away until the posterior edge of the spinous process was exposed. A high-speed drill (CORE, Stryker) with a 4-or 5-mm round cutting burr (Stryker Instruments, Kalamazoo, Michigan) was used (depending on the size of the spinous process) to drill away the spinous process (Figs. 2A and 3A). The spinous process was drilled away until the periosteal layers were visualized. The paraspinal muscles attached to the periosteal layer of the spinous process were not manipulated in any way, and the periosteal layers of the spinous process were left

TABLE 1. Summary of Results[a]

	Transspinous Laminotomies (n = 9)	Conventional Laminotomies (n = 9)	*P* Value (*t* Test)	Transspinous Discectomies (n = 11)	Conventional Discectomies (n = 11)	*P* Value (*t* Test)
Affected levels (no. of patients)	L2 (1), L3 (1), L4 (6), L5 (1)	L3 (1), L4 (7), L5 (1)	N/A	L2–L3 (1), L3–L4 (1), L4–L5 (7), L5–S1 (2)	L2–L3 (1), L3–L4 (1), L4–L5 (4), L5–S1 (5)	N/A
Avg. age (y)	56.9 [30-74]	63.7 [38-81]	N/A	51 [28-68]	42.9 [21-68]	N/A
Avg. BMI	30.2 [23.3-40.4]	30.6 [22.2-39.7]	.87	28.1 [21.8-45.2]	23.2 [20.1-26.3]	.035
Avg. estimated blood loss (mL)	45 [20-150]	76.1 [25-100]	.06	41.8 [10-100]	42.3 [20-75]	.95
Avg. incision length (cm)	3.94 [3-6]	5.97 [4.3-9]	**.0019**	2.93 [2-3.5]	4.1 [3.5-6]	**.0022**
Avg. inpatient length of stay (d)	1.55 [0-4]	1.89 [1-5]	.44	2.27 [1-8][b]	1.63 [1-4]	.65
Avg. inpatient postop IV narcotic analgesia use (mg)	5.33 [0-12]	7.33 [0-16]	.43	4.36 [0-8]	6.0 [0-12]	.32
Avg. inpatient postop oral narcotic analgesia use (mg)	32.22 [10-65]	38.13 [20-65]	.53	45.0 [10-70]	45.45 [30-70]	.96
RDQ-24 (preop)	19.2 [16-22]	19 [16-22]	.76	18.55 [15-23]	19.73 [17-23]	.24
RDQ-24 (1-wk postop)	4.5 [2-10]	7.11 [3-12]	**.005**	3.8 [1-10]	8.27 [4-18]	.13
BPI (1 mo postop)	0.49 [0-3]	0.67 [0-3]	.5	0.27 [0-2]	0.76 [0-2]	**.02**
RDQ-24 (1 y postop)	0.89 [0-3]	1 [0-3]	.84	0.55 [0-2]	1.82 [0-5]	**.043**
Avg. follow-up period at 1-y (mo)	14.5 [12.1-15]	14.1 [12.1-15]	N/A	14.1 [12.1-15]	14.1 [11.5-15]	N/A
No. of patients with symptom recurrence	1	1	N/A	1	1	N/A
Patient satisfaction at 1 mo postop	VS (7), S (2)	VS (6), S (3)	N/A	VS (9) , S (2)	VS (7) , S (3), NS (1)	N/A

[a] Statistically significant values are shown in bold, and the values in square brackets denote ranges. N/A, not applicable; Avg., average; BMI, body mass index; postop, postoperatively; IV, intravenous; RDQ-24, Roland-Morris Disability Questionnaire; BPI; Brief Pain Inventory; VS, very satisfied; S, satisfied; NS, not satisfied.
[b] Two patients required nursing facility placement.

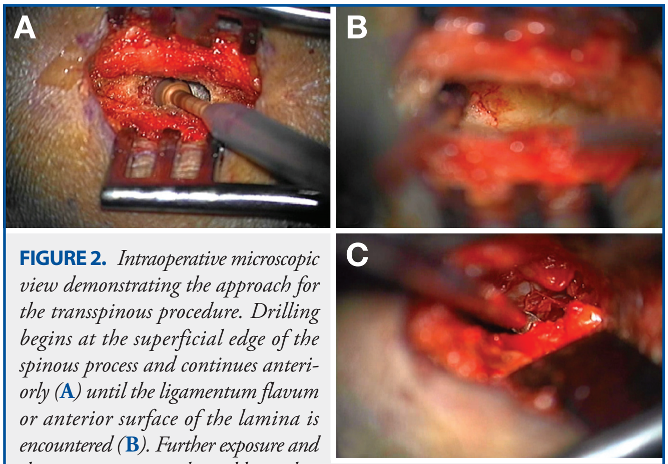


FIGURE 2. *Intraoperative microscopic view demonstrating the approach for the transspinous procedure. Drilling begins at the superficial edge of the spinous process and continues anteriorly (***A***) until the ligamentum flavum or anterior surface of the lamina is encountered (***B***). Further exposure and decompression are achieved by undercutting the lamina(e) and facets using a Kerrison punch (***C***).*

intact. We found that only the inferior half or inferior two thirds of the spinous process needed to be drilled away to facilitate adequate exposure of the spinal canal, hypertrophic facets, and lateral recesses. If indicated, the interspinous ligament below the spinous process of interest was split longitudinally to obtain further exposure. Once the operative site was too deep for direct visualized drilling, an operating microscope was brought into the field (Carl Zeiss Meditec, Jena, Germany, or Leica Microsystems GmbH, Wetzlar, Germany). If required, the self-retaining retractor was removed and a Williams self-retaining retractor (Codman and Shurtleff, Inc., Raynham, Massachusetts) was introduced to achieve better exposure and retraction. Drilling of the spinous process was continued until the anterior periosteal surface of the lamina or the posterior surface of the ligamentum flavum was encountered (Fig. 2B). If required, the lateral subperiosteal aspect of the laminae and superior facets were partially drilled away or undercut with a Kerrison punch (Codman and Shurtleff, Inc.). The ligamentum flavum was removed using Kerrison punch excision (at a 45-degree angle with a 1-, 2-, or 3-mm opening) so that the thecal sac was adequately decompressed. A Kerrison punch was used to partially undercut and remove the inner facets and widen the neural foramen (Figs. 2C and 3B). Visualization and exposure for removal of the hypertrophic facets and ligamentum flavum were accomplished by rotating the operating table along its long axis. An angulated microprobe was introduced along the nerve root to determine whether the neural foramens were adequately decompressed. After decompression was completed and careful hemostasis was achieved, the supraspinous ligaments were approximated

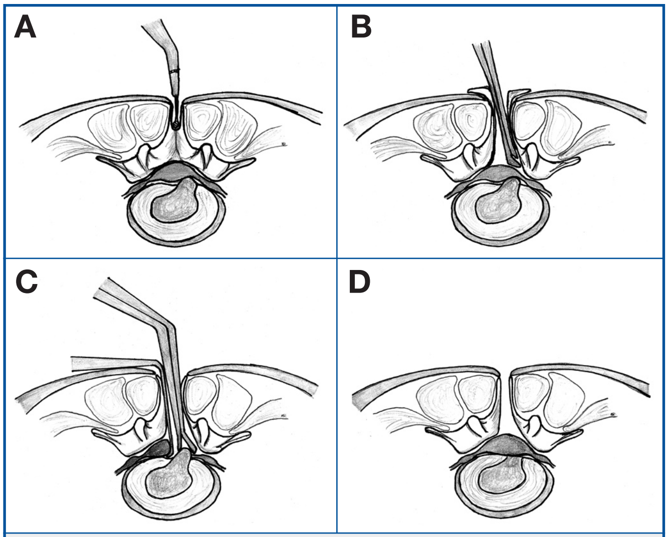


FIGURE 3. *Illustrations of the procedures used in the transspinous laminotomy and discectomy technique. The transspinous approach begins with subperiosteal drilling of the inferior half to two thirds of the spinous process that overlies the affected herniated disc (**A**). The ligamentum flavum is removed using Kerrison punch excision so that the thecal sac is adequately decompressed, and the inner facets are partially undercut, if required, to widen the neural foramen (**B**). A nerve root retractor is used to mobilize the nerve root to facilitate access to the herniated disc lying anteriorly. An opening is made in the herniated disc, with pituitary forceps and spinal curets being used to remove the herniated disc and its fragments (**C**). Note that the paraspinal muscles attached to the periosteal layer of the spinous process are not manipulated, and the spinous process that overlies the unaffected side is left intact as is the periosteal layer of the spinous processes that overlies the affected herniated disc (**D**).*

using 0 Vicryl sutures (Ethicon, Inc., Somerville, NJ) (Fig. 4C). The subcutaneous layers were approximated with 2-0 Vicryl sutures (Ethicon, Inc.), and the skin was closed with DERMABOND (Ethicon, Inc.).

Transspinous Lumbar Decompression With Discectomy

The initial localization and approach to the spinous process were similar to the technique as described previously for transspinous lumbar decompression. Once the spinous process is encountered, we have found that for patients undergoing a discectomy, only the lateral half to two thirds of the spinous process that overlies the affected herniated disc needs to be drilled, thereby preserving the remainder of the spinous process. It should be recognized that to have effective exposure and access to the herniated disc, the lamina on the affected side may need to be more aggressively drilled away laterally. No dissection of the paraspinal musculature was performed. Once adequate exposure was obtained, the area above the nerve root was decompressed as described previously in the transspinous decompression technique (Fig. 2C). A nerve root retractor was then used to mobilize the nerve root to facilitate access to the herniated disc lying anteriorly. A no. 11 blade was used to make an opening in the herniated disc. Pituitary forceps

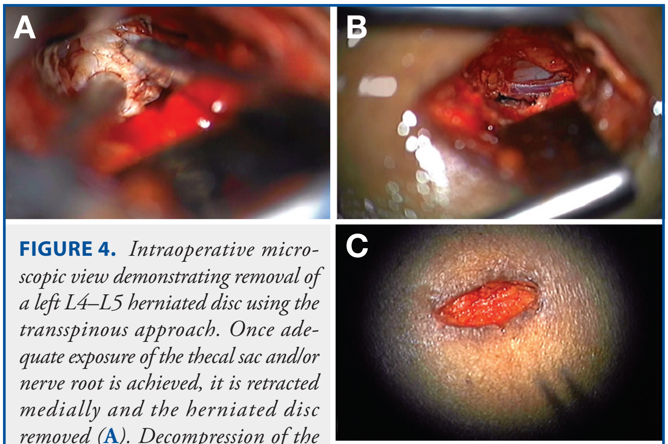


FIGURE 4. *Intraoperative microscopic view demonstrating removal of a left L4–L5 herniated disc using the transspinous approach. Once adequate exposure of the thecal sac and/or nerve root is achieved, it is retracted medially and the herniated disc removed (**A**). Decompression of the compressed thecal sac and nerve root is continued until it is adequate (**B**), and the supraspinous ligaments are approximated (**C**) before skin closure.*

and Epstein and spinal curets (Codman and Shurtleff, Inc.) were then used to remove the herniated disc and its fragments (Figs. 3C and 4A). Once adequately decompressed, the nerve root retractor was withdrawn (Figs. 3D and 4B). The remainder of the procedure was performed as previously described for a transspinous lumbar decompression.

The Conventional Approach

The conventional decompressive technique without discectomy was performed as previously described by Mixter[11] and Barr and Riseborough,[12] whereas the decompressive technique with discectomy was performed as previously described by Williams[42] and Yaşargil.[43]

Postoperative Care

All patients were allowed to ambulate immediately after surgery. Patients did not need to wear any supportive braces and did not require the assistance of ambulatory aides. Pain was controlled with the use of either nonsteroidal anti-inflammatory drugs or low-dose narcotic analgesics.

Outcome Evaluation

This study evaluated the outcomes of patients who underwent surgery in which either the transspinous or the conventional approach was used. The primary outcome was physical disability, measured using the Roland-Morris Disability Questionnaire (RDQ-24) (Fig. 5).[44] The secondary outcome was pain intensity, which was assessed using the Brief Pain Inventory (BPI).[45] Patient assessments were performed preoperatively and postoperatively at 1 week using the RDQ-24. This 24-item self-report measure of physical disability because of back and leg pain has established validity, reliability, and responsiveness to change and is simple and concise to complete.[25,46-49] In a study of 97 patients who had undergone lumbar surgery, Ostelo et al[47] compared the reproducibility and responsiveness of the RDQ-24 with those of 5 other scales, which included the Modified Roland-Morris Disability

The Roland-Morris Disability Questionnaire (RDQ-24)

When your back hurts, you may find it difficult to do some of the things you normally do. This list contains sentences that people have used to describe themselves when they have back pain. When you read them, you may find that some stand out because they describe you today. As you read the list, think of yourself today. When you read a sentence that describes you today, put a tick against it. If the sentence does not describe you, then leave the space blank and go on to the next one. Remember; only tick the box if you are sure it describes you today.

- ☐ I stay at home most of the time because of my back.
- ☐ I change position frequently to try to get my back comfortable.
- ☐ I walk more slowly than usual because of my back.
- ☐ Because of my back, I am not doing any jobs that I usually do around the house.
- ☐ Because of my back, I use a handrail to get upstairs.
- ☐ Because of my back, I lie down to rest more often.
- ☐ Because of my back, I have to hold on to something to get out of an easy chair.
- ☐ Because of my back, I try to get other people to do things for me.
- ☐ I get dressed more slowly than usual because of my back.
- ☐ I only stand up for short periods of time because of my back.
- ☐ Because of my back, I try not to bend or kneel down.
- ☐ I find it difficult to get out of a chair because of my back.
- ☐ My back is painful almost all of the time.
- ☐ I find it difficult to turn over in bed because of my back.
- ☐ My appetite is not very good because of my back.
- ☐ I have trouble putting on my sock (or stockings) because of the pain in my back.
- ☐ I can only walk short distances because of my back pain.
- ☐ I sleep less well because of my back.
- ☐ Because of my back pain, I get dressed with the help of someone else.
- ☐ I sit down for most of the day because of my back.
- ☐ I avoid heavy jobs around the house because of my back.
- ☐ Because of back pain, I am more irritable and bad tempered with people than usual.
- ☐ Because of my back, I go upstairs more slowly than usual.
- ☐ I stay in bed most of the time because of my back.

Notes:
1. The patient is instructed to put a mark next to each appropriate statement.
2. The total number of marked statements is added by the clinician.
3. Clinical improvement over time can be graded based on the analysis of serial questionnaire scores. If, for example, at the beginning of treatment, a patient's score was 12 and, at the conclusion of treatment, her score was 2 (10 points of improvement), we would calculate an 83% (10/12 x 100) improvement.
4. The questionnaire may be adapted for use on-line or by telephone.

Adapted from: Roland MO, Morris RW: A study of the natural history of back pain. Part 1: Development of a reliable and sensitive measure of disability in low back pain. Spine 8:141-144, 1983[47]

FIGURE 5. *The Roland-Morris Disability Questionnaire is a 24-item self-report allowing clinicians to assess pre- and postoperative physical disability caused by back and leg pain. The differences in pre- and postoperative scores determine whether improvement has occurred.*

Questionnaire, the short Roland-Morris Disability Questionnaire, the Physical Functioning Scale, the Role-Limitations-Physical scale of the SF-36 (36-question Short Form Health Survey), and the Main Complaint. The study determined that the RDQ-24 was superior and more accurate with a sensitivity of 94.6% and a specificity of 88.2%.

At 1 month postoperatively, patients were assessed using the self-administered BPI, which measures both the intensity of pain and the interference of pain in the patient's lifestyle.[50] Patients were finally assessed at approximately 1 year postoperatively to evaluate any long-term physical disability secondary to pain or either surgical procedure. Additional outcome measures such as length of inpatient hospital stay, intraoperative blood loss, incision length, and perioperative narcotic analgesia use was obtained from patient charts. The groups were compared using the *t* test statistical algorithm, with a *P* value ≤.05 being considered significant.

RESULTS

The results are summarized in Table 1. Preoperatively, the groups did not differ significantly with respect to age, level of lumbar pathology, insurance status, or type of analgesia used. All patients tolerated the procedure well. There were no postoperative wound infections, and none of the patients required blood transfusion. An unintended durotomy was encountered in 2 patients (1 patient underwent a conventional lumbar decompression and the other a transspinous decompression with discectomy). These 2 patients did not require primary repair, and there was no evidence of cerebrospinal fluid leak postoperatively. All patients were ambulatory either immediately after surgery or on the first postoperative day with exception of the 2 patients who had unintended durotomies. They were managed conservatively with bed rest and allowed to ambulate 48 hours after surgery.

Patients Undergoing Lumbar Decompression Only

The average body mass index for the transspinous and conventional groups was 30.2 and 30.6, respectively (not significant). The average amount of estimate blood loss for the transspinous and conventional groups was 45 mL and 76.11 mL, respectively (not significant). The average incision length was 3.94 cm (range 3-6 cm) and 5.97 cm (range 4.3-9 cm) for the transspinous and conventional approaches, respectively ($P < .05$).

The average preoperative RDQ-24 score for patients in whom the transspinous and conventional approaches were used was 19.2 (range, 16-22) and 19.0 (range, 16–22), respectively (not significant). The average RDQ-24 score 1 week postoperatively was 4.5 (range, 2-10) and 7.11 (range, 3-12) for transspinous and conventional approaches, respectively ($P < .05$). At 1 month, patients were assessed using the BPI. Six of the patients in whom the conventional approach was used required continued narcotic use, with the remainder requiring the use of light analgesics (nonsteroidal anti-inflammatory drugs) 1 month postoperatively. None of the patients in whom the transspinous approach was used required narcotic use, whereas 4 patients required the use of light analgesics 1 month postoperatively. The average pain score at 1 month was 0.49 and 0.67 for the transspinous and conventional groups, respectively (not significant). All patients had nearly complete resolution of their preoperative back and leg pain except for 1 patient from the transspinous group in whom a new right lower extremity radiculopathy developed 3 months postoperatively. This patient had grade I spondylolisthesis (present preoperatively), underwent transspinous lumbar decompression only, and, on presentation at 1 month, rated the pain as interfering with her walking ability (BPI score of 5 of a possible 10). She subsequently underwent L4–L5 anterior lumbar interbody fusion with percutaneous, minimally invasive L4–L5 posterior pedicle screw instrumentation and fusion without complication, and subsequently had partial resolution of her symptoms. Two patients (1 from each group) had residual lower extremity weakness. One patient presented 1 month postoperatively with weakness of the left anterior tibialis (strength, 4 of 5, unchanged from the preoperative assessment), and another pre-

sented with weakness of the left plantar flexors, although the strength had improved from 3 to 4 out of 5. Both of these patients underwent outpatient physical rehabilitation, with complete resolution in 1 patient, whereas the patient with weakness of the left plantar flexors continued to have some residual weakness (strength, 4 of 5). At 1 year (average, 14.3 months; range, 12.1-15 months), the average RDQ-24 score postoperatively was 0.89 (range, 0-3) and 1 (range, 0-3) for the transspinous and conventional approaches, respectively (not significant). None of the patients had indications for imaging at 1-year follow-up.

Inpatient postoperative narcotic use was less in the transspinous group, although statistically not significant. The average length of inpatient stay was 1.55 and 1.89 days for the transspinous and conventional groups, respectively (not significant). One patient who underwent transspinous decompression was discharged immediately after surgery from the post–anesthesia care unit with complete resolution of preoperative symptoms.

Patients Undergoing Lumbar Decompression With Discectomy

The average body mass index for the transspinous and conventional groups was 28.1 and 23.2, respectively ($P < .05$). The average amount of blood loss for both the transspinous and conventional groups was 42 mL. The average incision length was 2.93 cm (range, 2-3.5 cm) and 4.1 cm (range, 3.5-6 cm) for the transspinous and conventional approaches, respectively ($P < .05$).

The average preoperative RDQ-24 score for patients undergoing the transspinous and conventional approaches was 18.55 (range, 15-23) and 19.73 (range, 17-23), respectively (not significant). The average RDQ-24 score at 1 week postoperatively was 3.8 (range 1-10) and 8.27 (range, 4-18) for the transspinous and conventional approaches, respectively (not significant). At 1 month, patients were assessed using the BPI. Two of the patients who underwent conventional discectomies required narcotic use and 6 required the use of light analgesics. None of the patients in whom the transspinous approach was used required narcotic use, whereas 5 patients required the use of light analgesics. The average pain score at 1 month was 0.27 and 0.76 for the transspinous and conventional groups, respectively ($P < .05$). Six patients who underwent conventional discectomies had residual lower extremity radiculopathy (1 required re-exploration with removal of disc fragments 1 week postoperatively) compared with 2 patients who underwent transspinous discectomies (1 required re-exploration 6 weeks postoperatively). Two patients who underwent conventional discectomies had residual lower extremity weakness and were managed with outpatient physical therapy. One patient who underwent a transspinous discectomy had residual quadriceps weakness, although the strength had improved from a score of 2 to a score of 4 out of 5. This patient underwent physical therapy and subsequently regained full strength. At 1 year (average 14.1 months; range 11.5-15 months), the average RDQ-24 score postoperatively was 0.55 (range, 0-2) and 1.82 (range, 0-5) for the transspinous and conventional approaches, respectively ($P < .05$). None of the patients had indications for imaging at 1-year follow-up.

There was less inpatient postoperative narcotic use in the transspinous group, although statistically not significant. The average length of inpatient stay was 2.27 and 1.63 days for the transspinous and conventional groups, respectively (not significant). This longer inpatient length of stay in the transspinous group was attributed to the fact that there was difficulty in nursing home placement for 2 of the patients who required further management of their medical comorbidities.

DISCUSSION

Lumbar decompression is the most common procedure performed for lumbar spinal stenosis and lumbar spondylolisthesis.[19] Although problems with extensive tissue dissection, paraspinal muscle denervation, and possible resulting spinal instability can deter its complete success, conventional open decompressive techniques such as the laminectomy continue to be the gold standard for the treatment of such disorders.[7,8,18-20,22,29] The resulting tissue damage from these conventional techniques can also lead to increased postoperative pain and delayed recovery time.[4] To address these issues, a new minimally invasive technique, the transspinous approach, was used in patients undergoing single-level lumbar decompression with and without discectomy.

All patients underwent single-level lumbar decompression either with or without a discectomy. Across all measures, patients in whom the transspinous approach was used had better results and outcomes, although not all were of statistical significance (Table 1).

Preoperatively and 1 week postoperatively, the patients were assessed using the RDQ-24. All patients, regardless of surgical technique, demonstrated an improvement in their functional status. This was most evident in patients who underwent surgery in which the transspinous approach was used and was statistically significant in the group who underwent transspinous decompression only ($P < .05$). The patients were also assessed at 1 month postoperatively using the BPI to grade their pain intensity and its interference in their lifestyle. Again, the transspinous group had a better outcome, with statistical significance seen in those who underwent a transspinous decompression with discectomy. In 1 patient who underwent a transspinous decompression only, new right leg pain developed 3 months postoperatively. This subsequently required spinal instrumentation and fusion for her preexisting grade I spondylolisthesis. We believe that this recurrence of pain was caused by residual compression of the nerve root secondary to the spondylolisthesis. Because more decompression of the nerve root was required, the patient elected to undergo a more extensive procedure with spinal fusion. Long-term follow-up was assessed 1 year postoperatively using the RDQ-24. Although the transspinous group had a better outcome, statistical significance was only appreciated in those who underwent a transspinous decompression with discectomy.

Conventional open techniques require a wide exposure with significant tissue exposure and retraction that can lead to unavoidable tissue damage. This can cause muscle devitalization and denervation, which may lead to increased oxidative stress and the release of inflam-

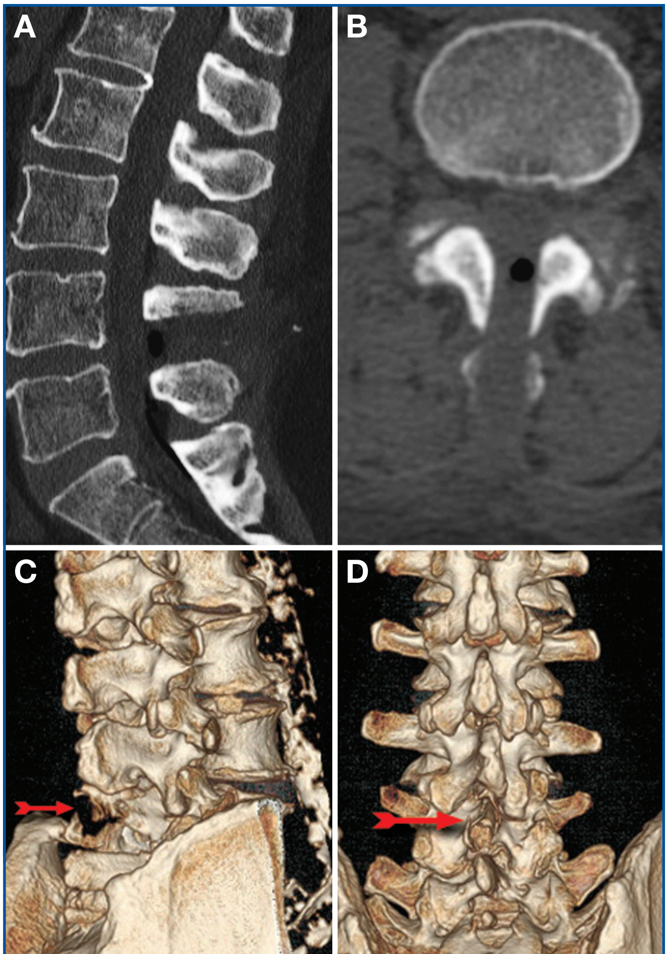
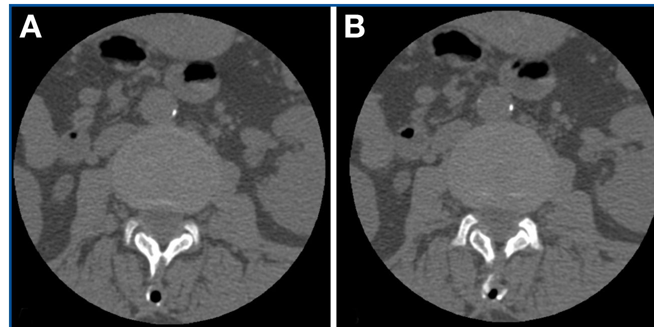


FIGURE 6. *Postoperative computed tomography images with 3-dimensional reconstructions after transspinous lumbar decompression. Postoperative sagittal (***A***) and axial (***B***) computed tomography images with 3-dimensional reconstructions (***C***,* **D***) after transspinous laminotomy of L4 with decompression of the L4–L5 level, revealing an intact superior portion of the L4 spinous process as well as the intact periosteal layers of the inferior portion of the L4 spinous process. The arrows (red) in the images correspond to the spinous process of L4 through which transspinous decompression was achieved.*



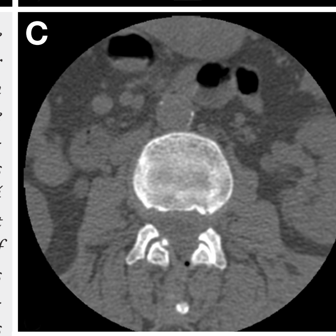


FIGURE 7. *Multilevel postoperative computed tomography images after transspinous lumbar decompression with microdiscectomy. Postoperative multilevel axial computed tomography images after transspinous laminotomy of L3 with left L3–L4 microdiscectomy, revealing intact superior and right lateral portions of the L3 spinous process (***A***) as well as the intact periosteal layers of the inferior portion of the L3 spinous process (***B***). Adequate decompression of the canal is achieved by undercutting the laminae (***C***).*

matory prostanoids and cytokines.[18,20,22,27,28,41,51-54] This in turn leads to inflammatory cell infiltration and the release of chemical pain mediators. Although no biochemical markers were drawn in this retrospective study, the transspinous technique avoids manipulation of the paraspinal muscles and eliminates the need for its retraction, thereby likely substantially minimizing the release of these chemical mediators and consequently reducing postoperative pain. This technique also affords early patient mobilization, thus reducing the risk of venous thrombosis, atelectasis, and pneumonias as well as the need for a urinary catheter and possible resulting urinary tract infections.

Other disadvantages of the conventional laminectomy technique include loss of the posterior osseous elements and paraspinal musculature, which has been reported to increase the incidence of spinal instability.[55] Other minimally invasive techniques[2,10,31,33-37,56] attempt to preserve osseous structures, but these still require stripping of the paraspinal musculature. The transspinous technique removes only the subperiosteal bone of the inferior or lateral aspect of the spinous process without manipulation of any musculature, thereby maximally preserving the osseous structures (Figs. 3D and 6). Data from experimental studies have demonstrated that partial removal of the interspinous ligament or subperiosteal layer of the spinous process is not related to spinal instability.[38,57]

Recently, minimally invasive techniques such as the spinous process–splitting laminectomy by Watanabe et al,[40] the chimney sublaminar decompression by Lin et al,[41] and the Marmot operation (split-spinous process laminotomy) by Cho et al[38] have been described to treat lumbar spinal stenosis. Although the techniques by Watanabe et al and Lin et al use laminectomies, the technique by Cho et al uses a laminotomy and an approach similar to ours. Yet our procedure differs from theirs in that the transspinous osteotomy is only performed at the area of interest. For transspinous decompression, only the lower half to two-thirds of the spinous process is drilled away, and the upper part of the interspinous ligament is split longitudinally. Likewise, for a transspinous discectomy, only the lateral half to two-thirds of the spinous process that overlies the affected side of the herniated disc is drilled away, thereby preserving the remainder of the spinous process (Figs. 3D and 7).

One of the disadvantages of the transspinous technique is that the operative duration can be longer than that using the conventional technique. Additionally, obtaining adequate exposure of

the lateral recess and neural foramen can be technically challenging. Becoming comfortable with drilling through the spinous process and working through a restricted opening can initially increase operating time, but with experience, we have seen this decrease to that of the conventional approach.

CONCLUSIONS

The transspinous approach allows effective spinal decompression and can also be used to adequately perform a discectomy. Although this procedure does provide some statistically significant improvement in outcomes over the conventional approach with respect to incision length, postoperative narcotic analgesia use at the end of 1 week, and pain at the end of 1 month and 1 year, for certain groups, the clinical significance of these differences is unclear. Nevertheless, like other minimally invasive approaches,[10,31-38,56] the transspinous approach can have other advantages, and these include causing no significant muscle or tissue damage, maintaining spinal stability, earlier mobilization, good functional neurological recovery, and an improved quality of life. As our experience with this new technique has grown, we have expanded it to treat multilevel stenoses with and without disc herniations as well as intradural lumbar lesions.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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